Electromagnetic Calorimetry

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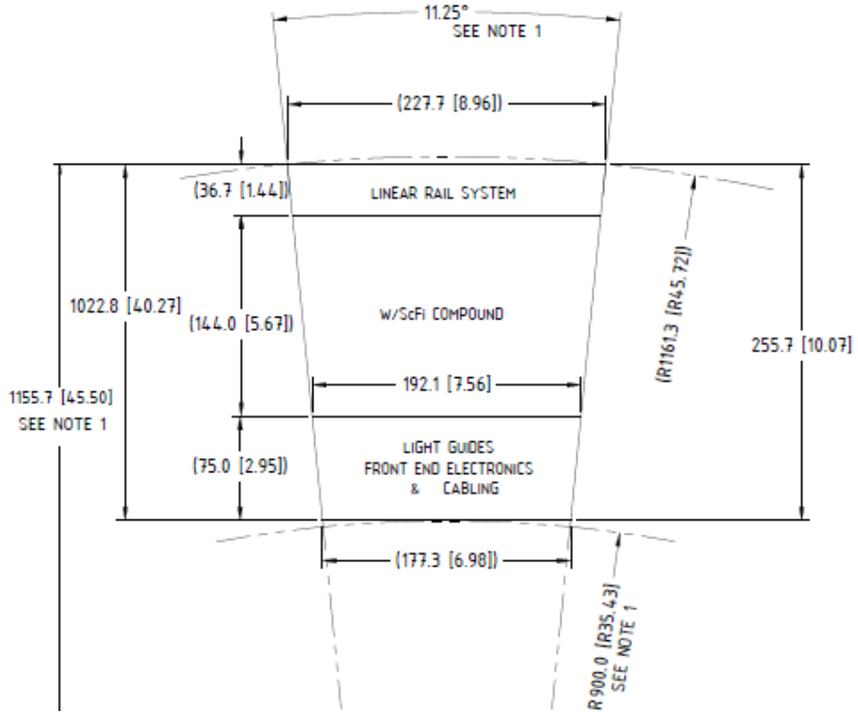
November 9, 2015

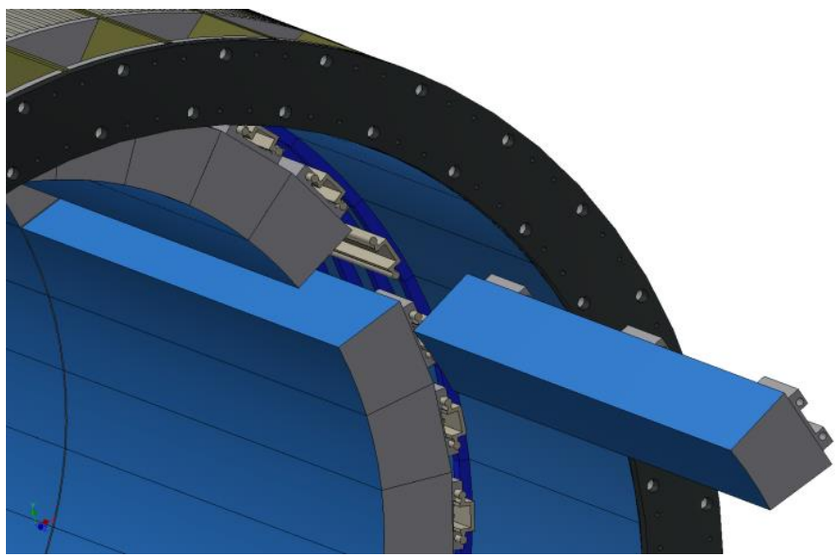
EMCal Performance Specs

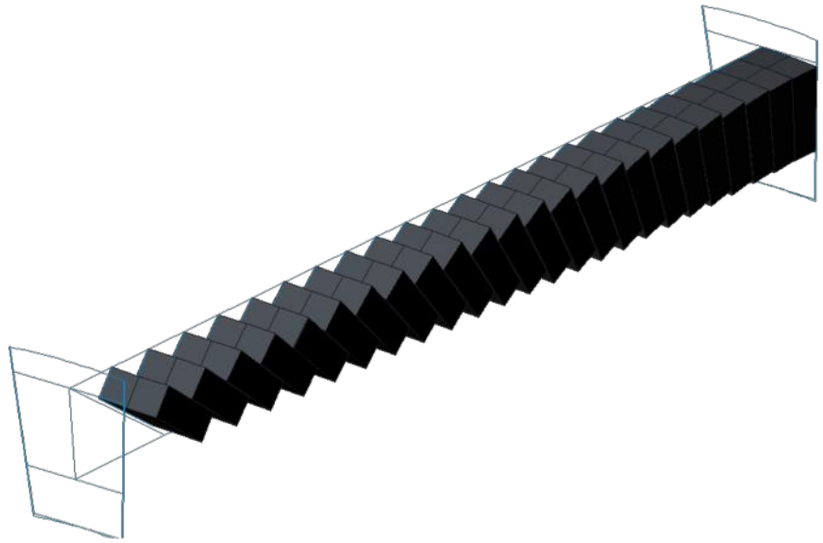
- energy resolution:
  - ~12%/√E, driven by γ and e± measurement
- acceptance over 2π and ±1.1 in η
- together with HCal provide good jet reconstruction in central AuAu collisions
- segmentation to allow 10 GeV γ reconstruction in central AuAu collision
- minimize radial space inside solenoid (allow room for inner HCal & tracking)
- density ~10g/cm3→X_0 = 7mm, R_M = 2.3cm
- 90x π rejection @ 70% electron eff. (=50% Y eff.)

Reference design



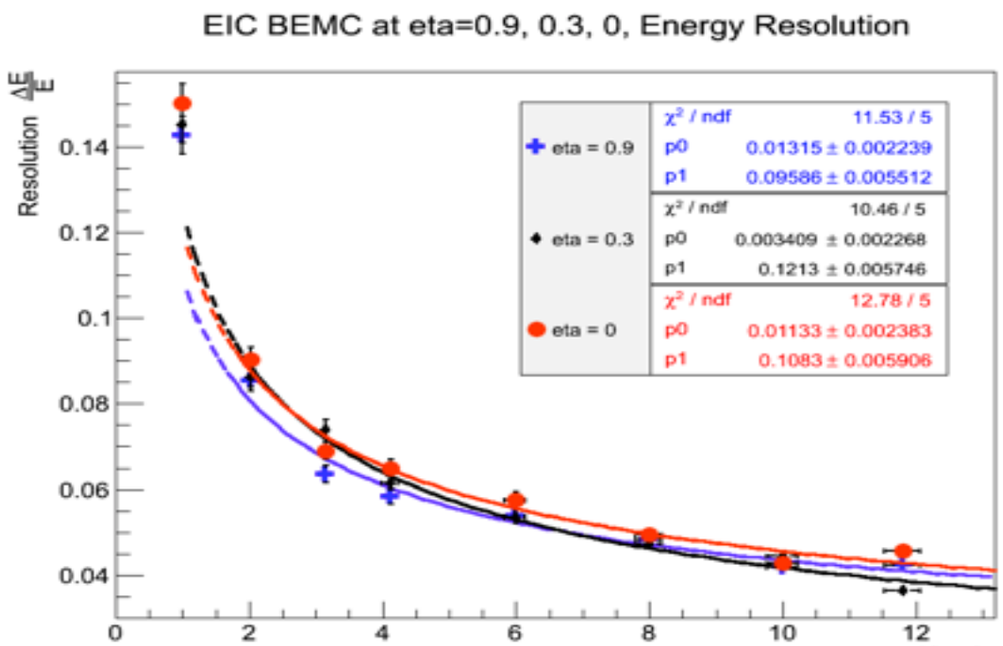
Parameter	Units	Value
Inner radius (envelope)	mm	900
Outer radius (envelope)	mm	1161
Length (envelope)	mm	$2 \times 1495 = 2990$
Number of towers in azimuth ($\Delta\phi$)		256
Number of towers in pseudorapidity ($\Delta\eta$)		$2 \times 48 = 96$
Number of electronic channels (towers)		$256 \times 96 = 24576$
Number of SiPMs per tower		4
Number of towers per module		$2 \times 8 = 16$
Number of modules per sector		24
Number of towers per sector		384
Number of sectors		$2 \times 32 = 64$
Sector weight (estimated)	kg	326
Total weight (estimated)	kg	20890
Average sampling fraction		2.3%

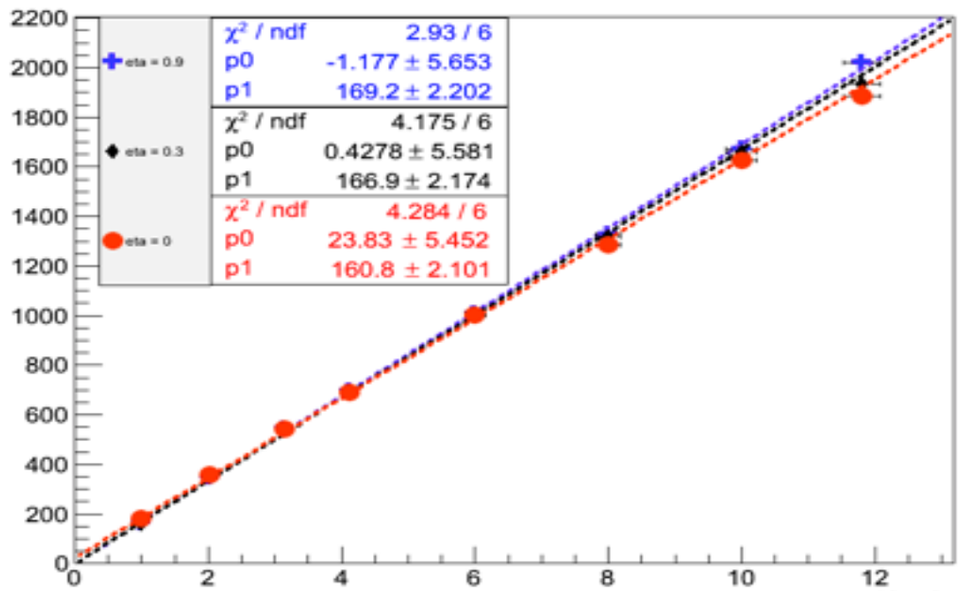




EMCal Performance—test beam

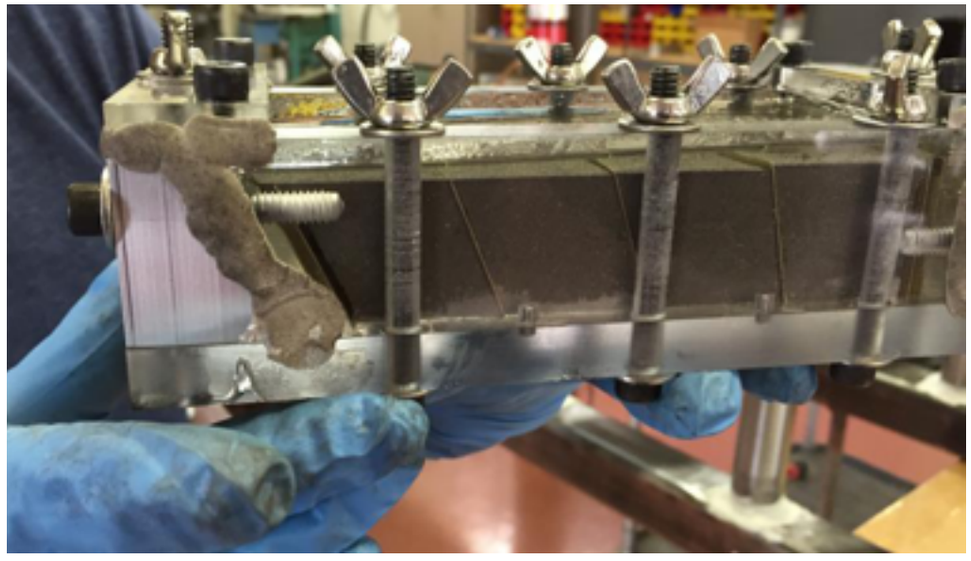
Energy resolution ~ 12%/√E





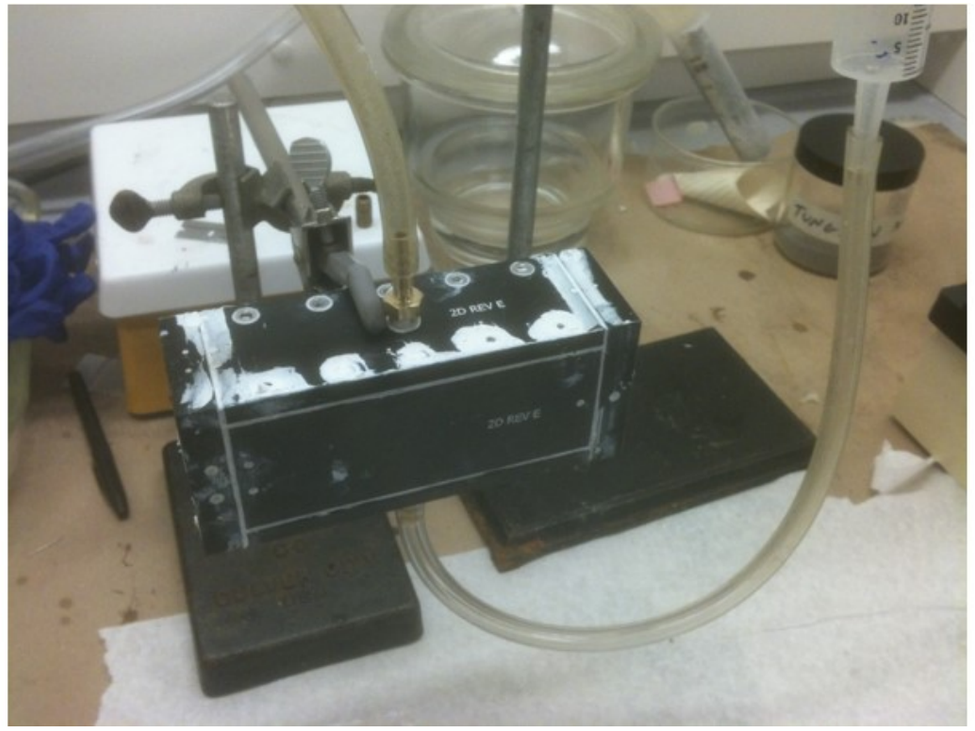
T-1018, O. Tsai, et al.

module production



- Modules are formed by pouring tungsten powder and epoxy into a mold containing an array of scintillating fibers

- Fibers are held in position with metal meshes spaced along the module



module production

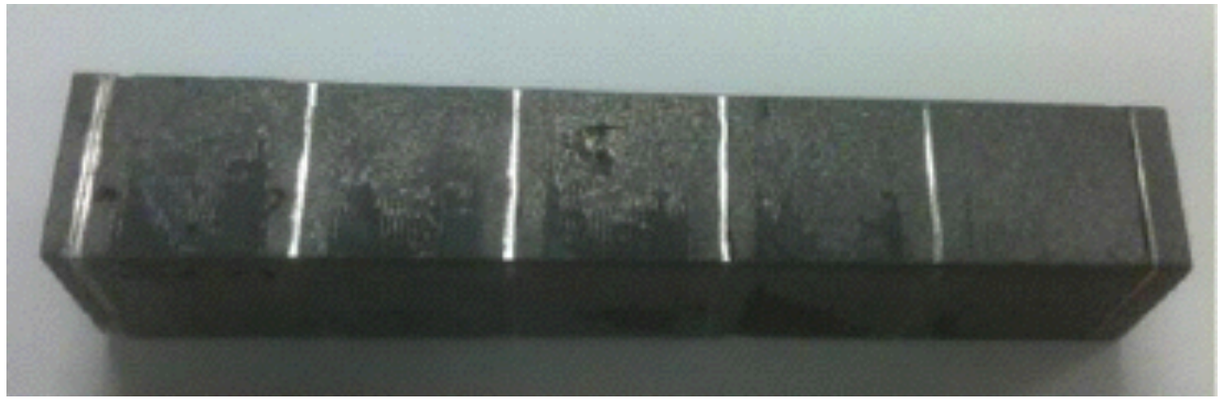
- developing production process w/ 1 & 2 D projective modules
- 1D projective modules:
  - density and fiber positioning tolerances
  - uniformity
  - epoxy filling
  - end machining
- 2D projective modules
  - fiber positioning

2D projective fibers

module production

BNL

2D Projective

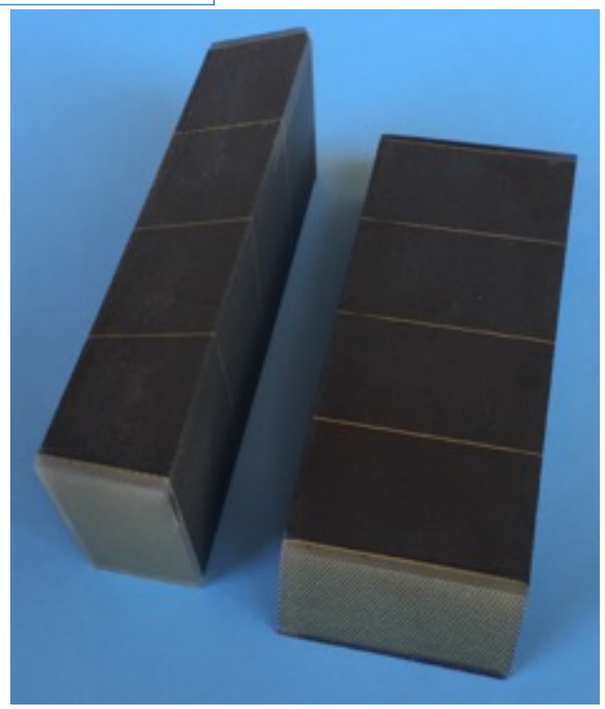


Illinois

1D Projective

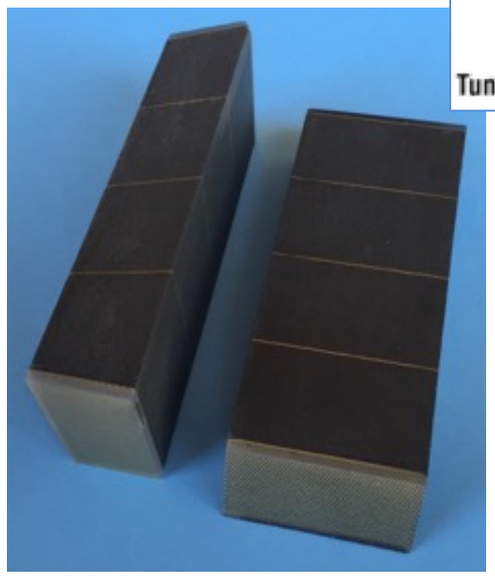
Tungsten HEAVY Powder, Inc. THP

1D Projective



prototyping

- **v1: 1D projective prototype**
  - 64 towers: 32 from THP, 32 from Illinois
  - combined EMCal/HCal testbeam April 2106 at Fermilab



Illinois

- **v2: 2D projective protoype**
  - 2D projective production processes in development
  - testbeam at Fermilab ~Oct/Nov 2016

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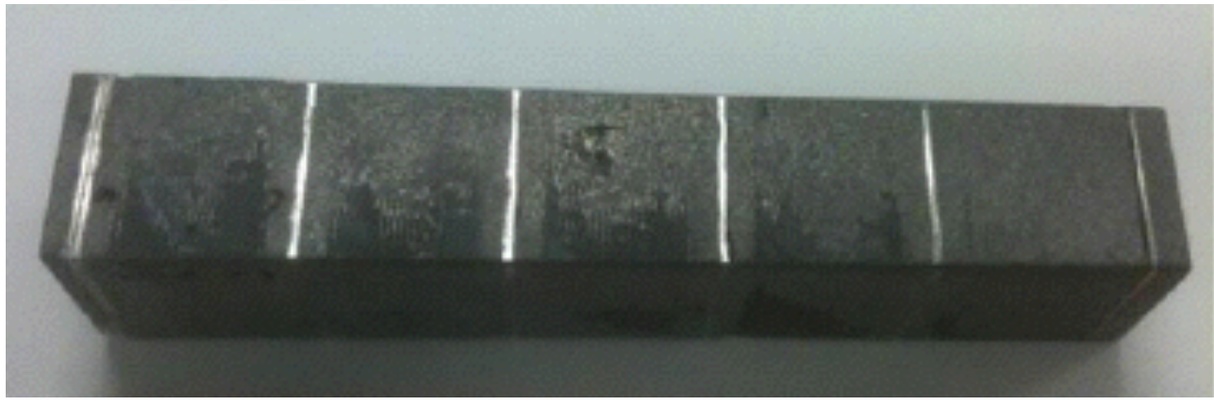
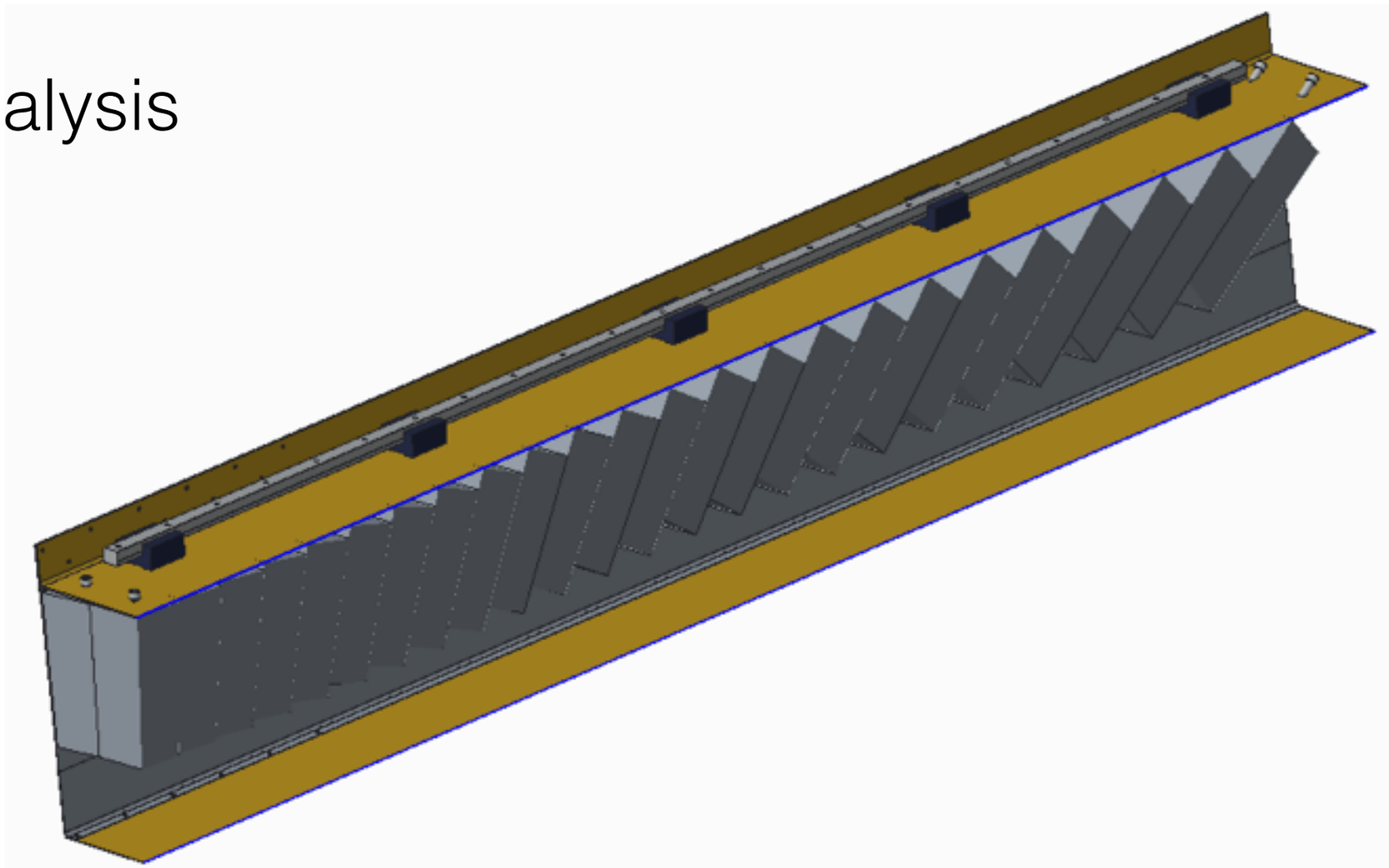


design

- issues
  - cables, cooling and electronics packing into the inner part to be done
  - cooling scheme to be developed and incorporated
  - deflection analysis

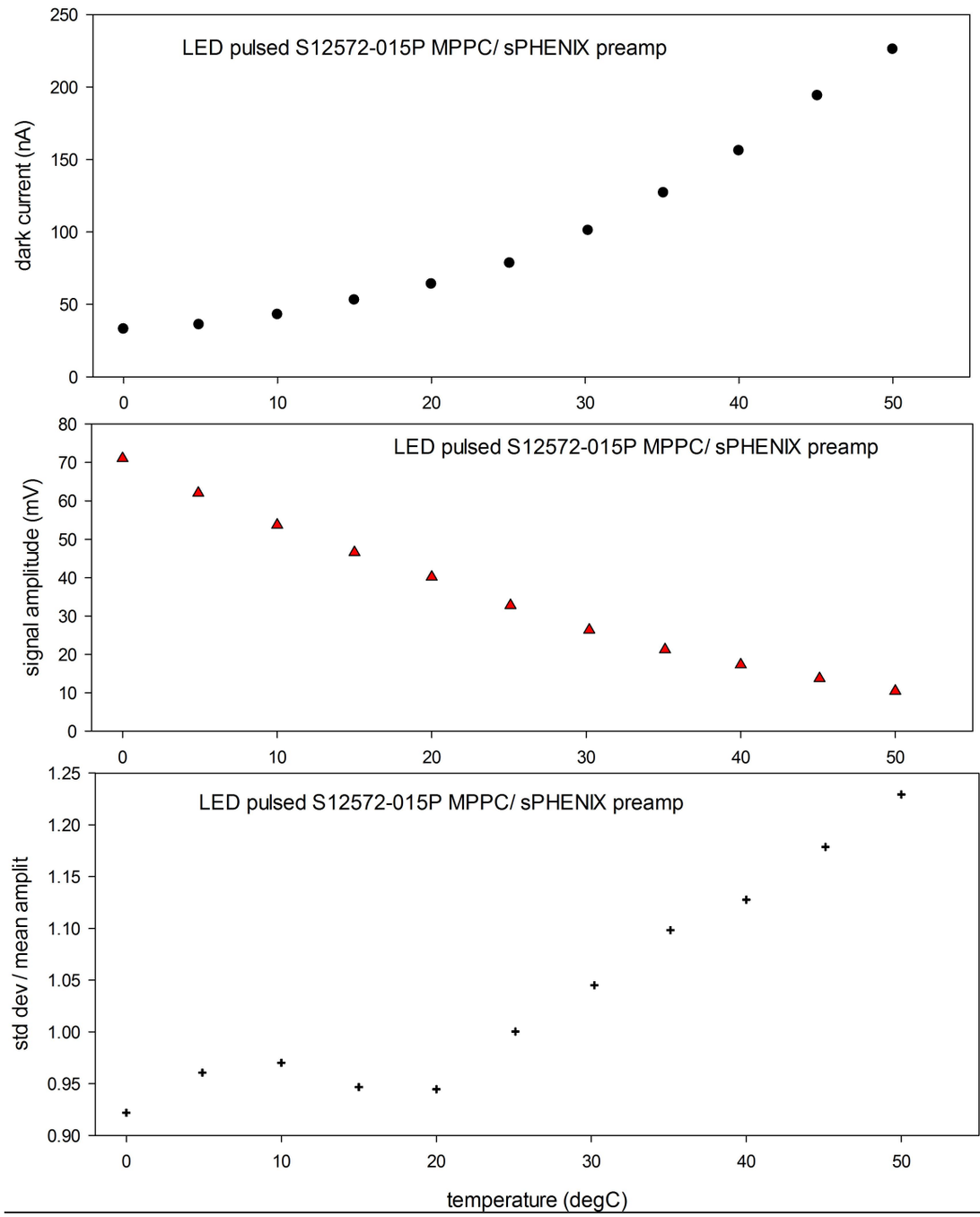


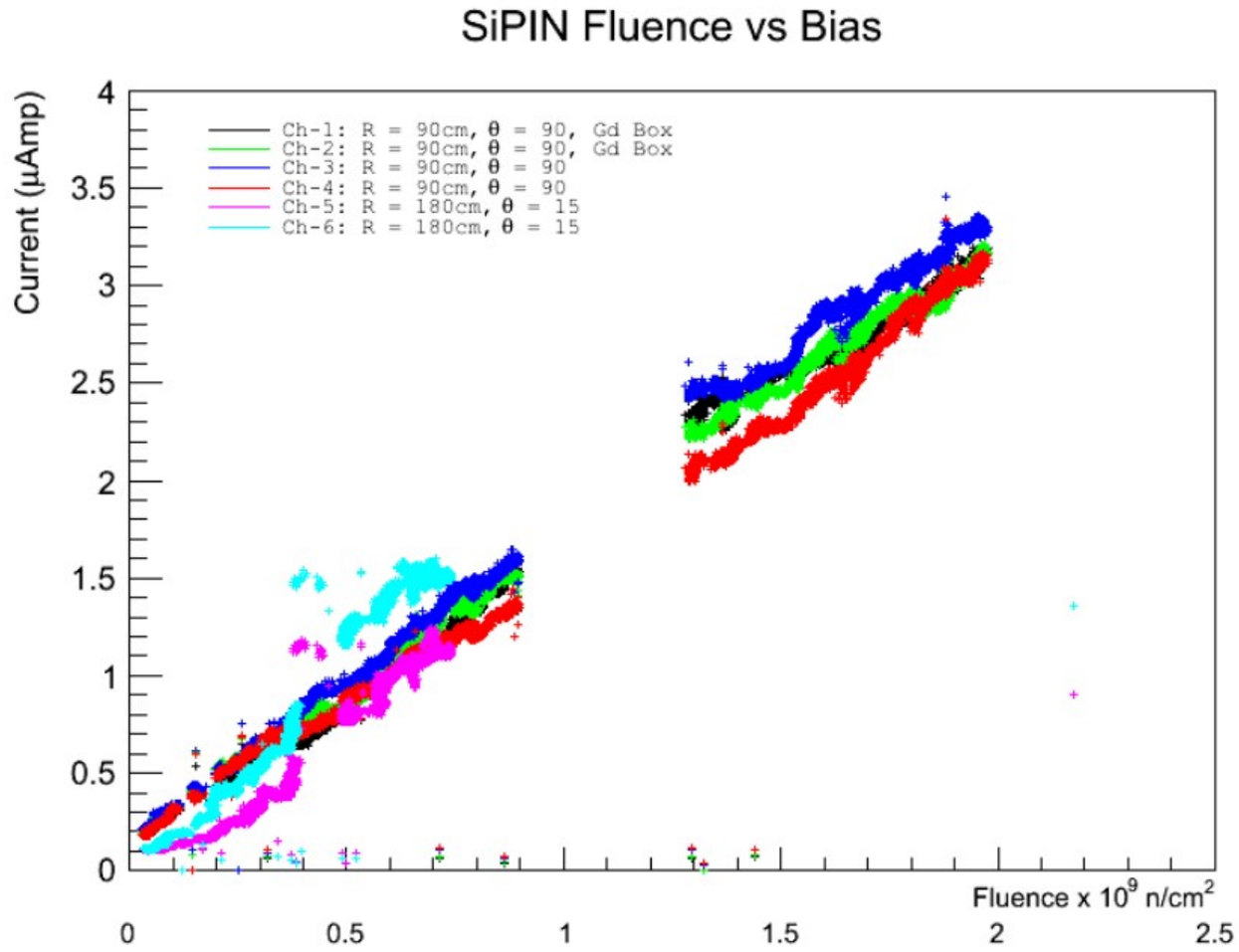
SiPMs

- reference design: same sensors to be used for EMCal & HCal
- reference device: Hamamatsu S12572
  - 15 μm2 pixel size
  - 40k pixels
  - 25% photon detection efficiency
  - spectral response: 320-900nm
  - concerns:
    - temperature dependence
    - radiation damage

SiPMs

temperature dependence, reference sensor



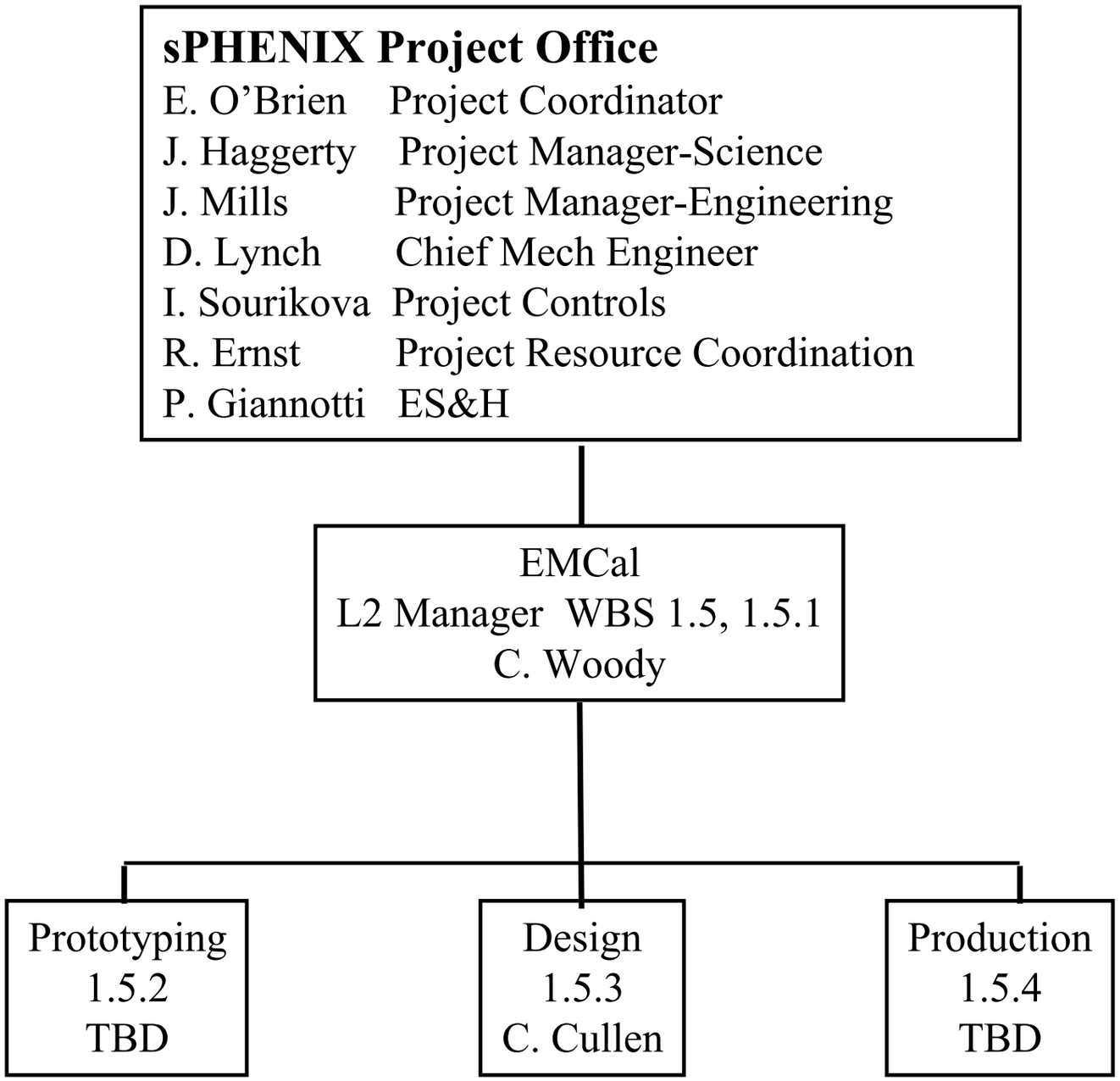


measurements of SiPM current in PHENIX IR during RHIC running

calorimeter electronics

- same sensor for EMCal and HCal
- similar readout for EMCal and HCal
- local temperature monitoring/gain stabilization
- LED based calibration system in preamp boards
- digitizer based on PHENIX HBD design
  - 65 MHz digitization / 14 bit ADC
- trigger primitives for L1 trigger
- utilize existing PHENIX DAQ, ~15kHz rate

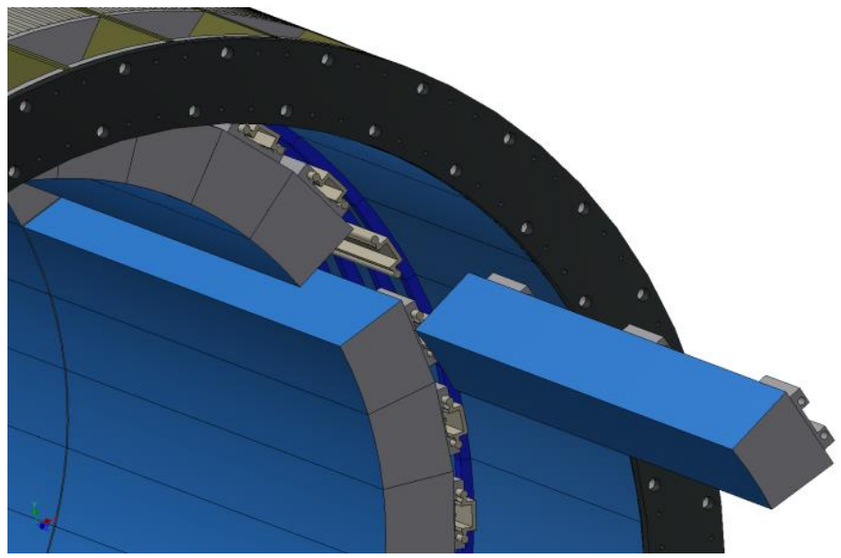
EMCal organization

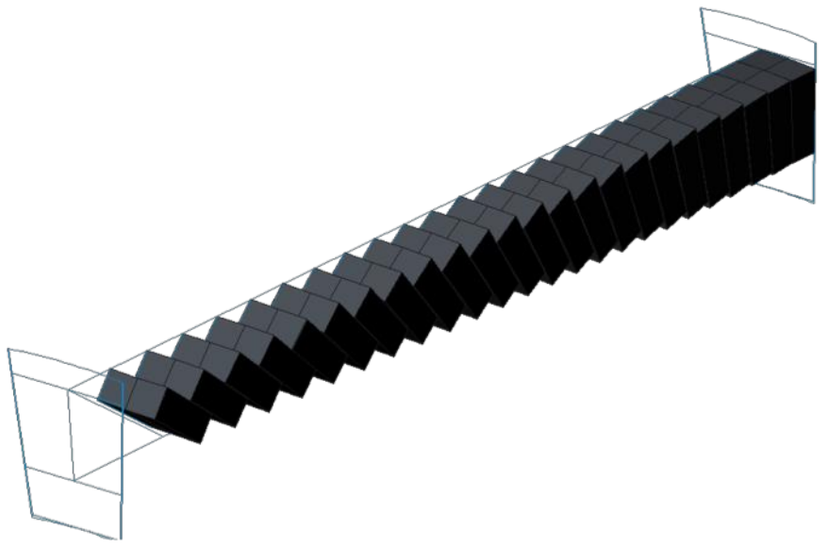


EMCal scope

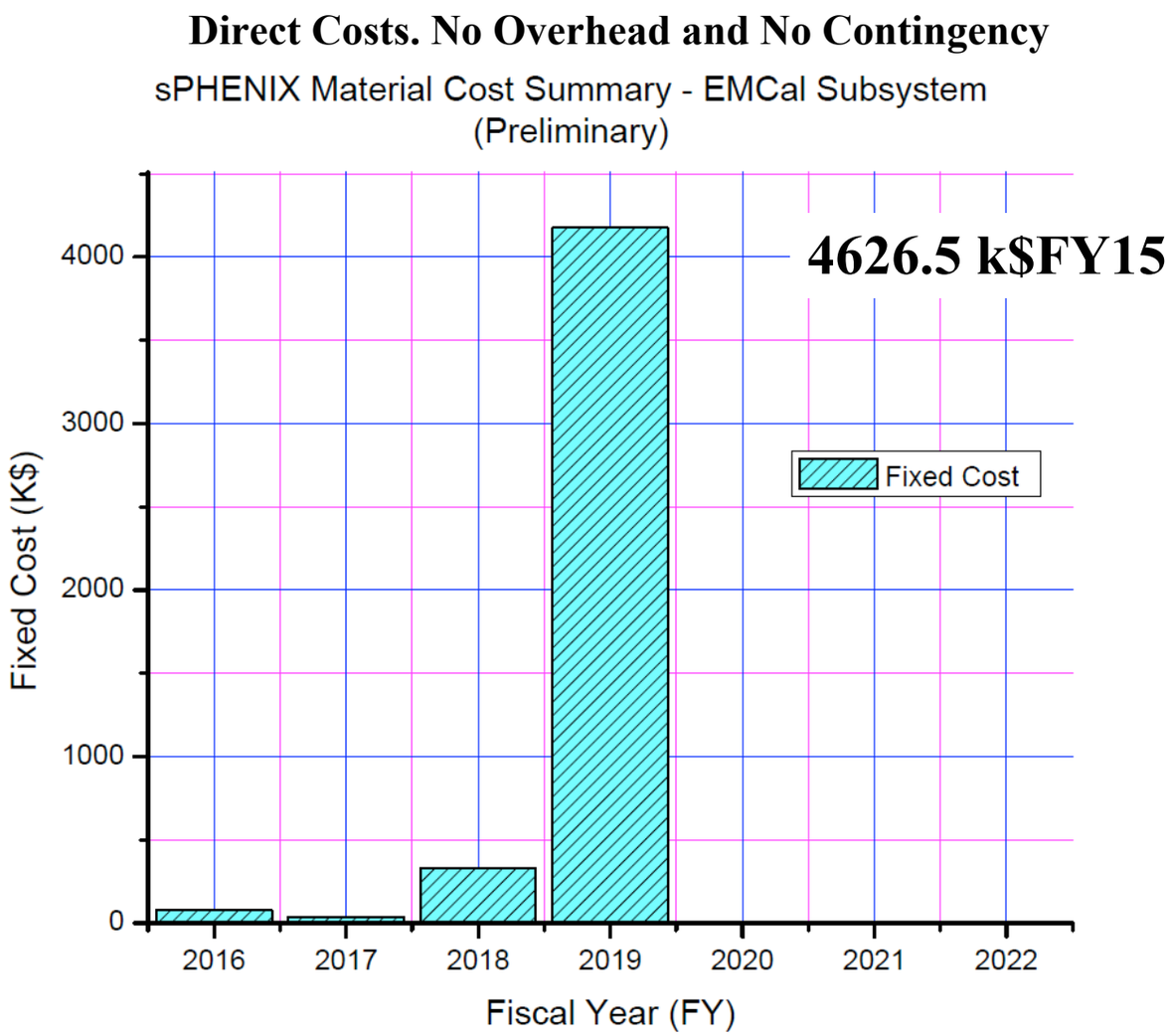
- 4 SiPM/tower: ~100k SiPM
- 3 rounds of prototyping
  - module production and assembly
  - 384 towers/sector
  - 64 sectors in full detector

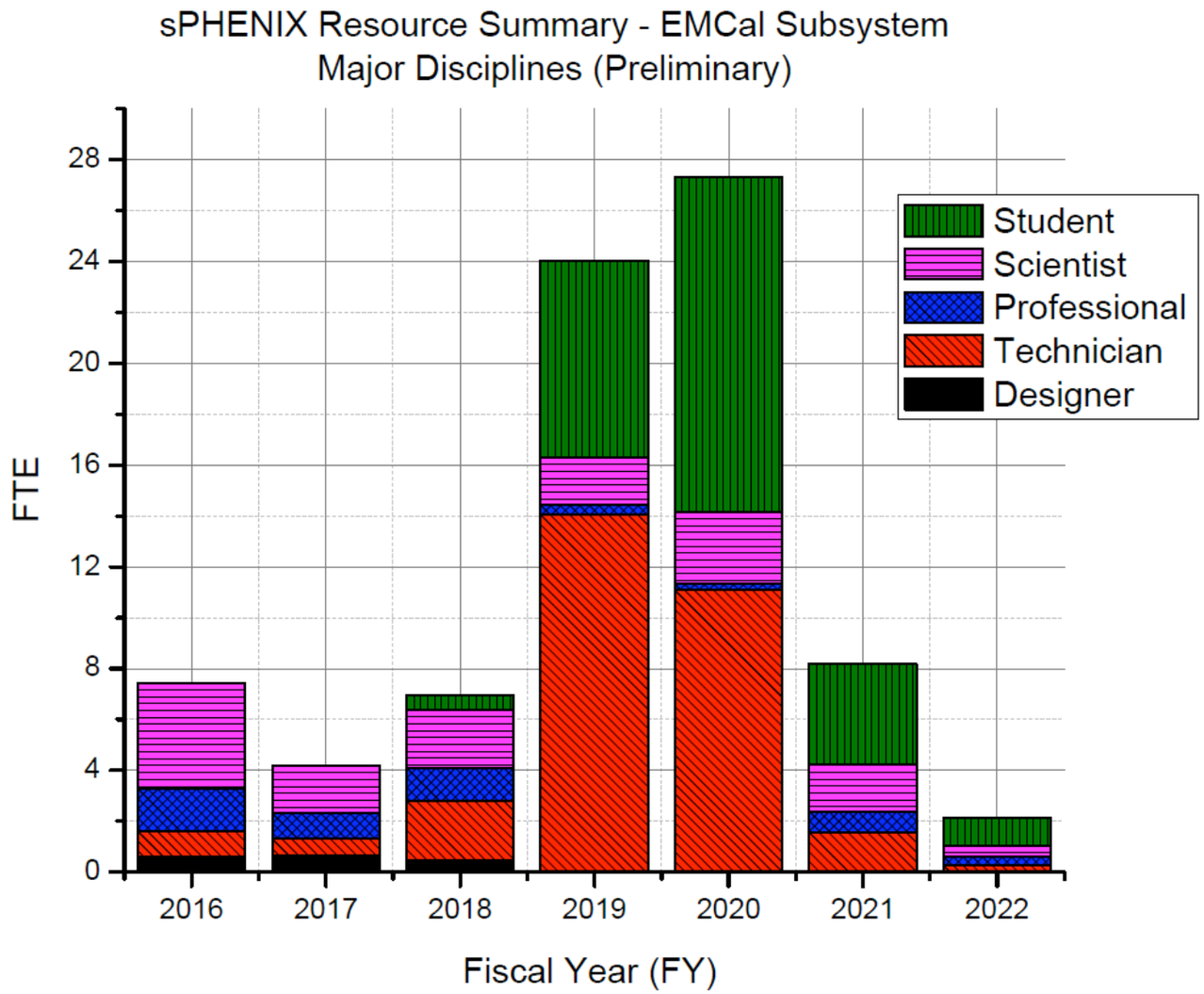
- 4 SiPM/tower
- calibration and integration into sPHENIX





EMCal budget/labor



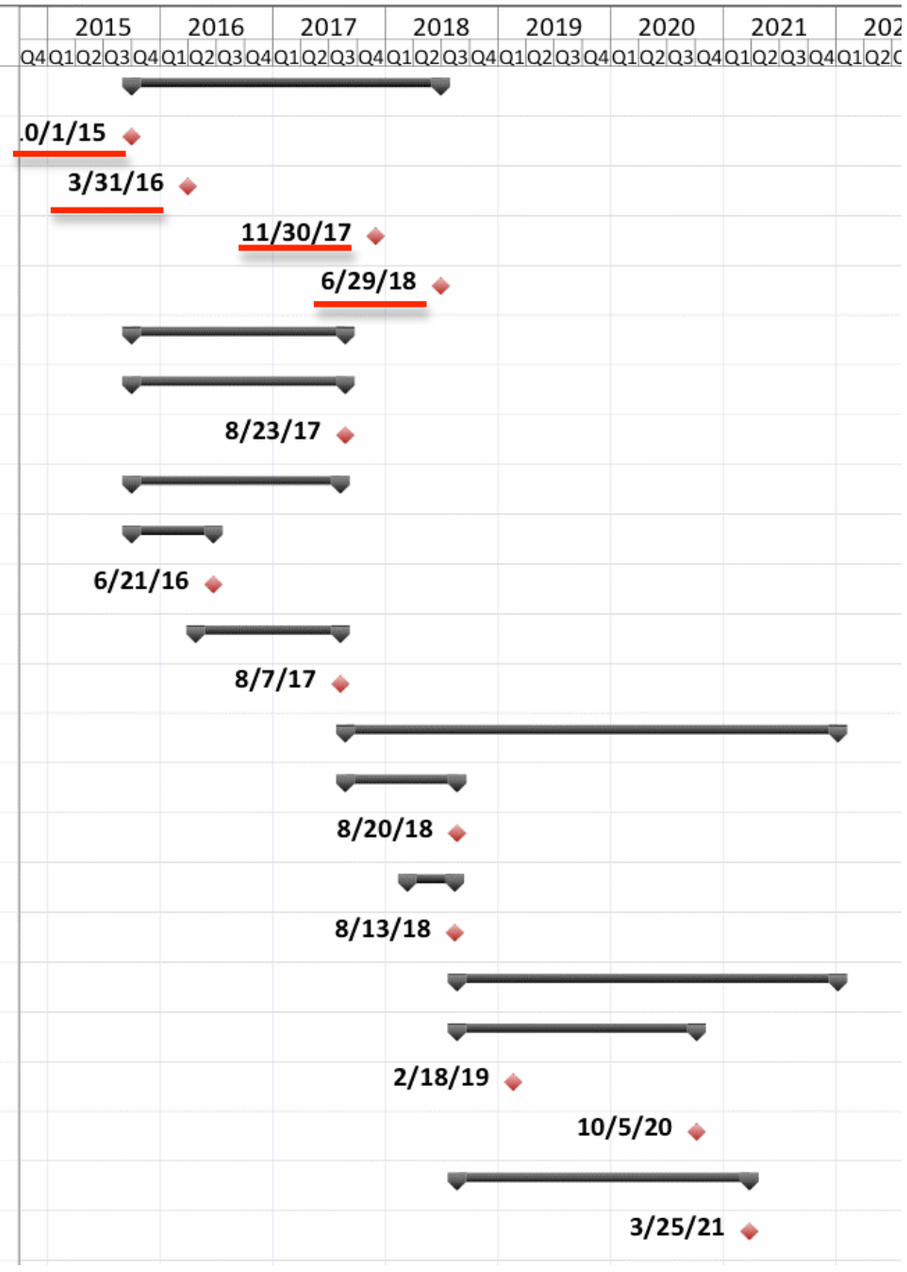


timeline

sPHENIX PROJECT SCHEDULE (Modified to fit updated DOE/CD Milestones)

Preliminary

ID	WBS	Task Name	Duration
1	**1.5.1**	**Project Milestones**	**645 days**
2	1.5.1.1	Start Pre R&D	0 days
3	1.5.1.2	Receive DOE CD-0	0 days
4	1.5.1.3	Receive DOE CD-1	0 days
5	1.5.1.4	Receive DOE CD-2/CD-3	0 days
10	**1.5.3**	**Preconceptual R&D**	**441 days**
11	**1.5.3.1**	**EMCal Preconceptual Design**	**441 days**
19	1.5.3.1.8	Complete Generic R&D Design	0 days
20	**1.5.3.2**	**EMCal Preconceptual Prototype**	**434 days**
21	**1.5.3.2.1**	**EMCal Prototype v1**	**173 days**
38	1.5.3.2.1.17	Complete v1 Prototype Work	0 days
39	**1.5.3.2.2**	**EMCal Prototype v2**	**301 days**
52	1.5.3.2.2.13	Complete v2 Prototype Work	0 days
53	**1.5.4**	**EMCal Project Tasks**	**1041 days**
54	**1.5.4.1**	**EMCal Preproduction Prototype**	**231 days**
84	1.5.4.1.31	Complete Preproduction Prototype Work	0 days
85	**1.5.4.2**	**EMCal Final Design**	**103 days**
93	1.5.4.2.8	Complete Final Design	0 days
94	**1.5.4.3**	**EMCal Production**	**810 days**
95	**1.5.4.3.1**	**EMCal Module Production**	**498 days**
102	1.5.4.3.1.7	Start Module Fabrication	0 days
106	1.5.4.3.1.11	EMCal Module Production Complete	0 days
107	**1.5.4.3.2**	**EMCal Module Assembly**	**606 days**
125	1.5.4.3.2.20	Complete Production and Assembly	0 days



schedule summary

v1 prototype	ongoing-Jun '16
v2 prototype	Jun '16- Aug '17
preproduction	Aug '17 - Aug '18
conceptual design	Apr '16 - Dec '17
technical design	Dec '17 - Jul '18
initiate production	Jul '18
tower fabrication	Feb '19 - Oct '20
supermodule	May '19 - Mar '21
ready for detector	Mar '21